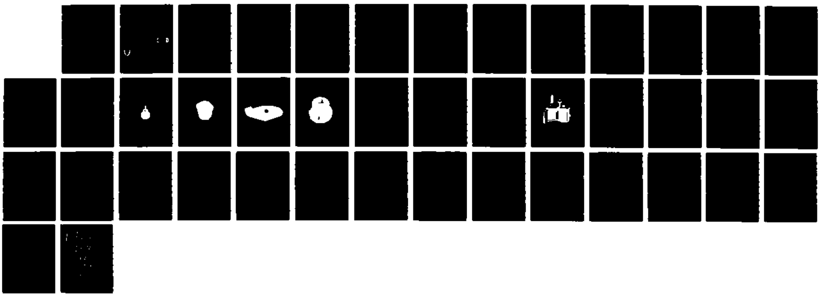
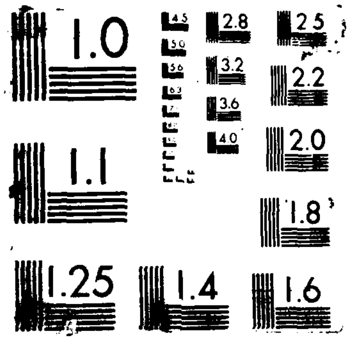
AD-A195 933 A NON-CONTACT THREE-DIMENSIONAL MEASURING SYSTEM(U) 1/1
ARMY ARMAMENT RESEARCH DEVELOPMENT AND ENGINEERING
CENTER WATERVLIET NY BENE T WEAPONS LAB D CONCORDIA
UNCLASSIFIED MAR 88 ARCCB-MR-88015 F/G 13/8 NL




1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

MEMORANDUM REPORT ARCCB-MR-88015

A NON-CONTACT THREE-DIMENSIONAL MEASURING SYSTEM

DAVID CONCORDIA

MARCH 1988

US ARMY ARMAMENT RESEARCH,
DEVELOPMENT AND ENGINEERING CENTER
CLOSE COMBAT ARMAMENTS CENTER
BENÉT LABORATORIES
WATERVLIET, N.Y. 12189-4050

DISCLAIMER

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

The use of trade name(s) and/or manufacturer(s) does not constitute an official indorsement or approval.

DESTRUCTION NOTICE

For classified documents, follow the procedures in DoD 5200.22-M, Industrial Security Manual, Section II-19 or DoD 5200.1-R, Information Security Program Regulation, Chapter IX.

For unclassified, limited documents, destroy by any method that will prevent disclosure of contents or reconstruction of the document.

For unclassified, unlimited documents, destroy when the report is no longer needed. Do not return it to the originator.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARCCB-MR-88015	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A NON-CONTACT THREE-DIMENSIONAL MEASURING SYSTEM		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) David Concordia		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army ARDEC Benet Laboratories, SMCAR-CCB-TL Watervliet, NY 12189-4050		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6126.23.1BL0.0 PRON No. 1A52GX3E1A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army ARDEC Close Combat Armaments Center Picatinny Arsenal, NJ 07806-5000		12. REPORT DATE March 1988
		13. NUMBER OF PAGES 35
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Non-Contact Measurement
Video Inspection
Three-Dimensional Measurement

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A non-contact video inspection system has been developed and implemented for inspection of small parts (smaller than 12 inches by 10 inches by 6 inches). The system uses a computer which processes the video image. Edge definition is determined through an algorithm which locates the point of maximum contact. Parts are located on a movable table, with table motion programmed through a user-friendly menu. Once a program is established for a particular part, the program can be rerun any number of times desired. Part inspection time has been reduced from hours to minutes.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

TABLE OF CONTENTS

TABLES

LIST OF ILLUSTRATIONS

STATEMENT OF THE OBJECTIVE

This project was initiated to provide Watervliet Arsenal with a system capable of measuring, in three dimensions, parts as large as 12"x10"x6", without contacting the part. Advanced Engineering Section, Engineering Support Branch, Benet Laboratories, was required to investigate available equipment, prepare a specification for purchase of a system, procure the system, and then develop programming for application to several small parts used at Watervliet. Also, during the development phase, by working with personnel from various Arsenal inspection groups, the area in which the system would ultimately be used was to be established.

BACKGROUND AND INTRODUCTION

Methods of improving the quality and reducing the time required to inspect parts is an ongoing effort. In recent years, because of developments in computer software and hardware, systems have become available that are capable of measuring dimensions of objects without contacting the part. The chief advantage of such a system is the speed with which it can make a measurement. When this project was initiated, it had become apparent to this section that this new technology could be successfully applied to the dimensional inspection of numerous small weapon components at Watervliet Arsenal.

APPROACH TO THE OBJECTIVE

Visits were made to three companies that manufacture non-contact measuring systems. All three systems were similar and were capable of measuring dimensions on sample parts manufactured at Watervliet. The inspection system consists essentially of four subsystems.

The first subsystem is the video camera which is mounted above the surface on which the part rests. The second subsystem consists of a movable surface that allows the part to be moved relative to the camera. The system which we eventually procured uses compressed air to provide movement of the table on a layer of air. Z-axis movement is accomplished by movement of the camera up and down. The third subsystem is the printer which prints results of the measurements. The fourth subsystem is the computer which controls operation of the total system. The computer incorporates software which allows for programming the system via a menu. The menu provides user-friendly instructions to the operator for programming the table and camera movements. Once the program is established it can be stored on the computer disc for repeated inspection of like parts. Location of edges on the part is accomplished by an algorithm within the computer software which determines the point of maximum contrast appearing through the video camera. The system is capable of making up to 100 measurements at 3 seconds per measurement.

RESULTS

Contract award for the system was made to Optical Gaging Products of Rochester, New York. This system explained in Appendix A and shown in Figure A-1, was installed within Benet in May 1986 for initial testing. The project officer received training for programming the system in June 1986. The contract included training for up to three individuals.

Following the training, efforts began to prepare programs for two parts that are examined by Arsenal incoming inspection. A program was successfully written and applied to one of the parts, a firing pin, shown in Figure 1. The

other part, shown in Figure 2, could not be programmed. Because this part contained areas recessed below the surface and had a black coating on its surface, the video camera did not receive enough light to discern an edge. The time required to program the inspection of the firing pin was about 3 weeks because it was a learning process for the programmer. An experienced programmer would be able to program this particular part in about 3 days. The part inspection requires measurement of about 30 dimensions and takes about 3 minutes compared to an inspection time of about 1 hour by conventional methods. Appendices B and C give a listing of the program for the firing pin and an example of output from the printer. Table I gives the range in values obtained for 10 consecutive runs versus measurements made by inspection personnel using conventional methods.

As indicated in Table I, some of the measurements were made at high magnification. The reason for using high magnification is to increase the accuracy of the measurement. The increased accuracy is not necessary on measurements where the tolerance is one one-hundredth (0.01) of an inch or larger since the system is accurate to the third decimal place at low magnification. It is desirable to use low magnification, when possible, since it provides a larger field of view than high magnification, thereby decreasing the chances of the system "missing" an edge during the inspection run. The field of view is 0.56 inch with a magnification of 23X at low magnification and 0.070 inch with a magnification of 185X at high magnification.

Since the part would probably not be placed in alignment with the axis of the table, the initial steps of the program are used to establish a reference axis and origin for future measurements.

The 0.13-0.002 inch dimension represents a diameter. The measurement was made using back lighting of the part, which produces a silhouette. The system is then programmed to move to a nominal point location on both edges of the silhouette where the 0.13-inch nominal diameter is located. The distance traveled by the table, from point to point, when corrected to the reference axis, represents the diameter measurement. When the table moves to a programmed nominal location, it searches for a point of maximum contrast and will search a distance up to four times the tolerance. This allows the system to locate the "true" edge of the part. The measurements show close agreement to the forth decimal place for the 0.13-inch diameter.

Measurement of the 45° ± 1° angle required experimenting with a variety of techniques in order to achieve satisfactory repeatability. The problems encountered with the measurement resulted from the small tolerance (±1°) over a short distance (a nominal distance of 0.028 inch). The technique which ultimately produced the best repeatability was to locate 40 points on the edge formed by the angle, and use the angle formed by the line of best fit for these points, as the measured angle. Similar difficulty in measuring this angle using conventional methods is apparent from the relatively wide variation in readings (i.e., 44°20' to 45°43').

One measurement, the concentricity requirement of ±0.001 inch for the 0.872 diameter, was measured within the same programming step used to measure the 0.872 diameter. This was possible because the system software contains an algorithm which calculates the center point for diameter measurements. This feature eliminates the need for an additional programming step to check the concentricity.

The remaining dimensional measurements showed satisfactory agreement between values obtained using the measuring system versus conventional methods. All variations in values obtained, using the two methods, occurred at least one decimal place to the right of the tolerance position.

Two additional parts manufactured at Watervliet were programmed to verify that the system was capable of inspecting parts typical of those manufactured or used at Watervliet, shown in Figures 3 and 4. The inspection programs for these parts proved to be satisfactory, so at that point it was felt that the usefulness of the system had been successfully demonstrated. Initially, consideration was given to using the system for incoming inspection, since this installation is required to inspect large volumes of incoming parts. However, there was concern over scratching the glass surface (the part support structure has glass, on which the part rests) and concern over use of the system in an area that did not have temperature control and air filtration. Because of these concerns, the system will be used by Quality Assurance Directorate since they have laboratory-type facilities in which to house the system. As a result, the system has been moved to their building, and their personnel will receive assistance from the project officer in learning to use the equipment. In addition, two of their personnel will attend training in parts programming at the contractor's facility.

Verification of the system accuracy is accomplished by comparing measurements made by the system on a glass reticle versus measurements by a calibration laboratory. Table II shows the laboratory measurements, as well as the measurements made by the system. System specifications call for an accuracy of ± 0.00035 inch.

CONCLUSION

The three-dimensional, non-contact measuring system has proven to be capable of inspecting a variety of parts manufactured and used at Watervliet Arsenal. The speed at which the system can operate will significantly reduce inspection time for a large number of parts. There are a number of parts, such as those with a black finish and those that have small enclosed areas, for which the system cannot be used because of insufficient reflection of light from the part surface. However, the number of parts for which the system can be used should more than justify its use as an inspection tool.

TABLE I

COMPARISON OF MEASUREMENTS FOR THE FIRING PIN
(Units are inches, except for angle measurements)

Required Dimension	Measuring System Range (10 Runs)	Conventional Methods
* .13-.002	.12811-.12855	.1281-.1284
5/32±1/64	.1589 -.1613	.155
.50 + .01	.5066 -.5070	.5049
* .853 + .002	.8535 -.8539	.8530
.02 + .01	.0241 -.0255	.0256
* 45° ± 1°	45.0589°-45.4239°	44°20'-45°-43'
* .872-.002	.87094-.87166	.8715
* 0 ± .001	.00000-.00084	.0007
*1.275 - .005	1.2725 - 1.2731	1.2730
.085 - .01	.0805 - .0815	.0807
.132 ± .01	.3136 - .3139	.3144
1/32 ± 1/64	.0304 - .0378	.0308 - .0370
.50 - .01	.4957 - .4969	.4975 - .4976

* High Magnification Measurements

TABLE II

CALIBRATION REPORT

O.G.P. VIDICOM INSPECTION RETICLE P/N 424658

S/N: 193 DATE: 7/23/85

The nine calibrated reference circles are located with respect to a coordinate system whose zero is point No. 1 and whose X-axis is parallel to the line joining points 4 and 6.

POINT NUMBER	X - DIMENSION	Y - DIMENSION
1	0	0
2	3.75034	- .00201
3	7.49962	- .00050
4	7.49954	-2.75116
5	3.75021	-2.75152
6	.00133	-2.75116
7	.00006	-5.50265
8	3.75010	-5.50136
9	7.50116	-5.50147
The two reference squares have center widths of:		
.025 square	.02549	.02541
.250 square	.25047	.25026

The values reported are considered to be in error by no more than 0.00010 inch, with 99% confidence. Measurements are traceable to N.B.S. via lead screw calibrations made with a frequency stabilized He-Ne laser accurate to 1 part per million as well as a glass master scale that has been checked by both N.B.S. (Cal. Report S0024 N/0024R) and N.R.C., Ottawa (APOP -202).

Robert McMahon

R. McMahon, Inspector

E. Loewen, Program Manager

TABLE II (CONT'D)

PROGRAM NAME	RUN #	DATE	TIME
HRGRID_193	7		

Blk	Function	Label	Sym	Nom.Val.	Act.Val.	U. Tol.	L. Tol.	Dev>Nom	Tol Exc
POSITION REFERENCE									
1	DIAMETER		DIA	.01500	.01482				
		NOM LOC	X	.00133	.00133				
			Y	-2.75116	-2.75116				
			Z	0.00000	0.00000				
ANGLE REFEPENCE (MANUAL SET)									
2	DIAMETER		DIA	.01500	.01500				
		NOM LOC	X	7.49954	7.49952				
			Y	-2.75116	-2.75116				
			Z	0.00000	0.00000				
3	NOM LOCAT		X	0.0000	0.0000				
			Y	0.0000	0.0000				
			Z	0.0000	0.0000				
4	DIAMETER		DIA	.01500	.01467				
		NOM LOC	X	0.00000	-0.00000				
			Y	0.00000	-.00007				
			Z	0.00000	0.00000				
		RESET	X	-0.00000	0.00000				
			Y	-.00007	0.00000				
5	NOM LOCAT		X	0.0000	0.0000				
			Y	0.0000	0.0000				
			Z	0.0000	0.0000				
6	DIAMETER	#1	DIA	.01500	.01469				
		NOM LOC	X	0.00000	.00001	.00035	.00035	.00001	+
			Y	0.00000	.00002	.00035	.00035	.00002	+
			Z	0.00000	0.00000				
7	NOM LOCAT		X	3.7503	3.7503				
			Y	-.0020	-.0020				
			Z	0.0000	0.0000				
8	DIAMETER	#2	DIA	.01500	.01469				
		NOM LOC	X	3.75034	3.75034	.00035	.00035	-0.00000	-
			Y	-.00201	-.00187	.00035	.00035	-.00014	--
			Z	0.00000	0.00000				
9	NOM LOCAT		X	7.4996	7.4996				
			Y	-.0005	-.0005				
			Z	0.0000	0.0000				

TABLE II (CONT'D)

Blk	Function	Label	Sym	Nom.Val.	Act.Val.	U. Tol.	L. Tol.	Dev>Nom	Tol Exc
10	DIAMETER	#3	DIA	.01500	.01462				
		NOM LOC	X	7.49962	7.49958	.00035	.00035	-.00004	-
			Y	-.00050	-.00032	.00035	.00035	-.00018	---
			Z	0.00000	0.00000				
11	NOM LOCAT		X	7.4995	7.4995				
			Y	-2.7512	-2.7512				
			Z	0.0000	0.0000				
12	DIAMETER	#4	DIA	.01500	.01503				
		NOM LOC	X	7.49954	7.49955	.00035	.00035	.00001	+
			Y	-2.75116	-2.75104	.00035	.00035	-.00012	--
			Z	0.00000	0.00000				
13	NOM LOCAT		X	3.7502	3.7502				
			Y	-2.7515	-2.7515				
			Z	0.0000	0.0000				
14	DIAMETER	#5	DIA	.02800	.02768				
		NOM LOC	X	3.75021	3.75022	.00035	.00035	.00001	+
			Y	-2.75152	-2.75155	.00035	.00035	.00003	+
			Z	0.00000	0.00000				
15	NOM LOCAT		X	.0013	.0013				
			Y	-2.7512	-2.7512				
			Z	0.0000	0.0000				
16	DIAMETER	#6	DIA	.01500	.01484				
		NOM LOC	X	.00133	.00137	.00035	.00035	.00004	+
			Y	-2.75116	-2.75112	.00035	.00035	-.00004	-
			Z	0.00000	0.00000				
17	NOM LOCAT		X	.0001	.0001				
			Y	-5.5027	-5.5027				
			Z	0.0000	0.0000				
18	DIAMETER	#7	DIA	.01500	.01478				
		NOM LOC	X	.00006	.00017	.00035	.00035	.00011	++
			Y	-5.50265	-5.50266	.00035	.00035	.00001	+
			Z	0.00000	0.00000				
19	NOM LOCAT		X	3.7501	3.7501				
			Y	-5.5014	-5.5014				
			Z	0.0000	0.0000				
20	DIAMETER	#8	DIA	.01500	.01473				
		NOM LOC	X	3.75010	3.75017	.00035	.00035	.00007	+
			Y	-5.50136	-5.50150	.00035	.00035	.00014	++
			Z	0.00000	0.00000				
21	NOM LOCAT		X	7.5012	7.5012				
			Y	-5.5015	-5.5015				
			Z	0.0000	0.0000				

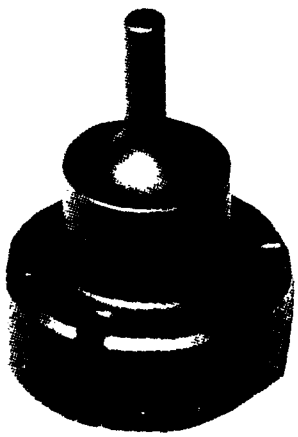


FIGURE 1 - FIRING PIN

(8 in, 155-mm, 175-mm Block Assembly)

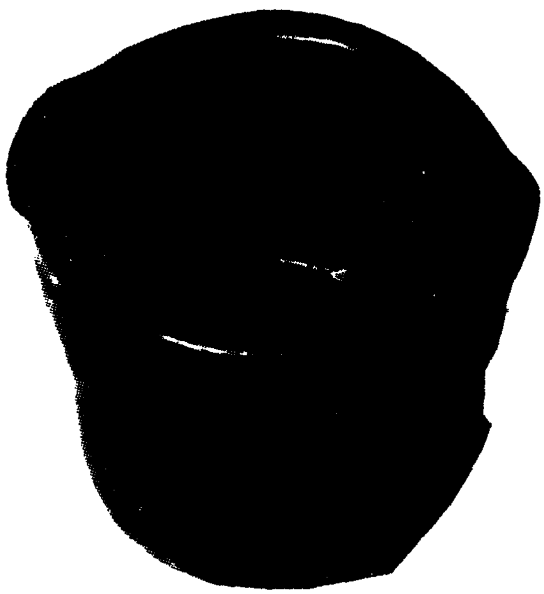


FIGURE 2 - CASE

(8 in, 155-mm, 175-mm Firing Mechanism)

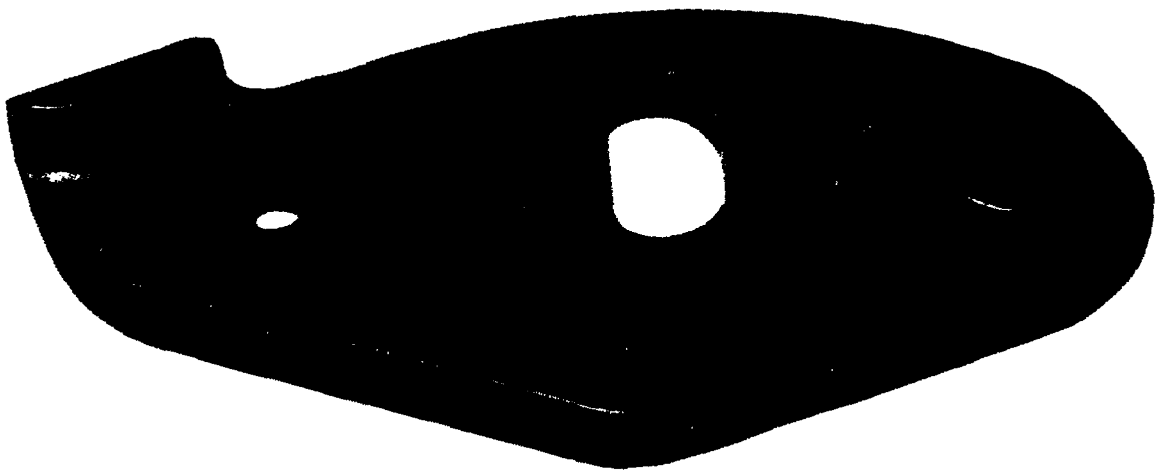


FIGURE 3 - EXTRACTOR

(105-mm M68 Extractor Assembly)

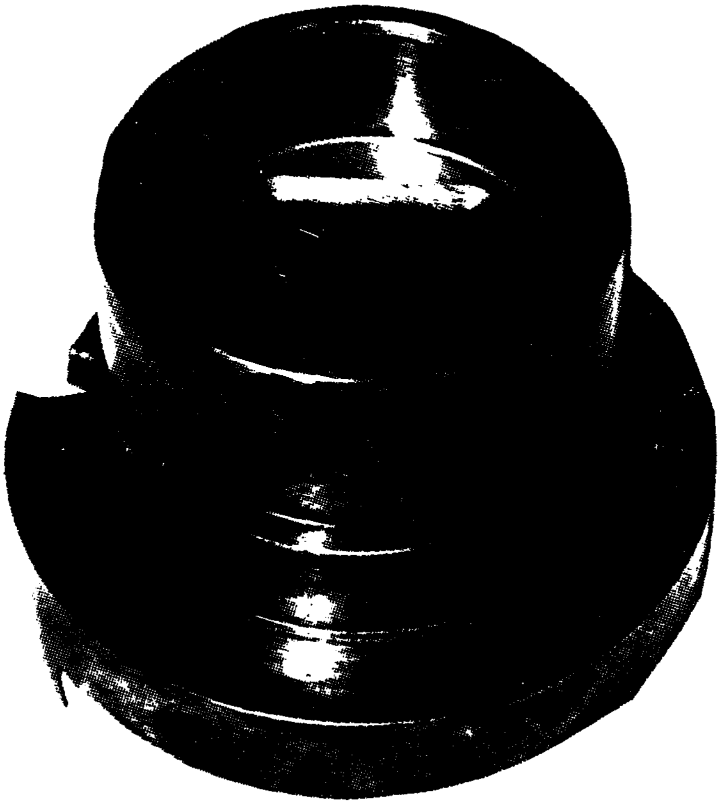


FIGURE 4 - ADJUSTOR

(105-mm M68 Breech Mechanism)

APPENDIX A

VIDICOM QUALIFIER 1210 PERFORMANCE SPECIFICATION

.EFFECTIVE JANUARY, 1984

PART NUMBER 530100 (VQ-1210-26)

1.0 INTRODUCTION: The purpose of this specification is to define systems configurations and performance criteria for the Vidicom Qualifier 1210 automatic non-contact video inspection center. The standard system includes a Hewlett Packard HP9826 calculator.

2.0 SYSTEMS CAPABILITIES

2.1 SIZE OF PARTS (format):

The stage of the VQ-1210 has 12" X-Axis, 10" Y-Axis motion and 6" Z-Axis motion. Any part fitting within this volume can be fully illuminated and viewed.

The horizontal worktable is 13" x 19 1/2", it contains a glass workstage integral to the worktable. A variety of staging slots and tapped holes are provided to accommodate standard contour projector fixtures as described in current Contour Projector Accessory Catalogs.

The worktable assembly is removable and interchangeable to accommodate quick changeover fixturing.

2.2 VIDEO VIEWING AREA

The camera assembly is a General Electric Model TN-2500 solid state camera. This sensor is a CID type, having 248 x 244 picture elements.

The optical system produces a field of view of .56" at "LOW" magnification. At "HIGH" magnification the field is .070". The approximate magnification of an object is 23X low, and 185X high, as seen on the video screen. The maximum video resolution is 1 part in 5000 of the field of view.

During automatic operation an object or feature is located within the field of view automatically by the system. A horizontal/vertical cross hair is placed at the proper location on the viewing screen to identify the found feature. Magnification change is instantaneous and automatic.

2.3 SOFTWARE CAPABILITY

The User Software (VIDICOMP II) will run on any Hewlett-Packard Series 200 Computer configured properly. Standard software will support a large range of external devices (Printer, Mass Storage) through the built-in HPIB Interface.

All inspection programs are generated by pressing labeled control buttons to select options from a "menu". Refer to VIDICOMP II Software Specification, Part No. 520165.

3.0 GENERAL MACHINE SPECIFICATIONS

3.1 PHYSICAL

Size: Length 79"(2007mm), width 48"(1219mm), Height 73"(1854mm) max.
Weight: 1250 lbs. approximately, 1450 lbs. crated.
Table Height from floor: 44 1/2" (1130mm)
Stage Throat Clearance: 10" (254mm) maximum, 4"(102mm) minimum

3.2 OPTICAL

Focal Clearance: 4" (102mm)
Distortion (Optical): .05% maximum
Resolution: Electro Optical: .0002" (.005mm) low mag.
.00002" (.0005mm) high mag.
Field of view (diagonal): .560" (14mm) low mag.
.070" (1.75mm) high mag.
Depth of Field: .100" (2.54mm) low mag.
.005" (.127mm) high mag.

3.3 ELECTRICAL

Power: 115 VAC ±10%, 6.0 Amps, 50/60Hz (2.4 Amps-9826)
Service: 3-wire power cord, U.S. plug
Controls: Power, Stop, Hi-Mag, Move CL, Zero X-Y-Z
Motion Direction Buttons (6), Illumination.
Joy Stick for Stage and Centerline Control.
Illumination: Profile, Surface, Adjustable or Fresnel Quadrature
Displays: Position and image - 12" C.R.T., with text generator display
Machine Status - Status Panel
Video Controls: Edge, Angle, Circle

3.4 MECHANICAL

Stage Travel: X-12"(305mm), Y-10" (254mm), Z-6" (152mm)
Stage Type: X-Y Hydrostatic Air-Bearing, Z Ballslide
Position Transducer: Incremental Linear Glass Scale (X, Y, Z)
Position Resolution: X,Y .00004"(.001mm), Z-Axis .0001 (.002mm)
Maximum Table Load: 200 lbs.
Drives: DC Servo Motors - X & Y, Stepping Motors - Z
Pneumatic Shop Compressed Air: 75 PSIG, 4 SCFM Maximum

3.5 HEWLETT-PACKARD MODEL 9826

Program Space Required: 306 K Bytes
Maximum Programs per Disc: 6
Maximum Memory: 2.5 M Bytes
Maximum Blocks/Program: 200 (without links see Software Specification #520165 Section 4.2)
Program Name Size: up to 50 characters (first 10 must be unique)
Display: 7" Diagonal C.R.T.
Display Buffering: 2 K Byte - Alpha, 16 K Byte Graphics
Keyboard: Typewriter Keyboard with Numeric Keypad, Special
Functions Key, Full ASCII Character Set.
Tone Generator Variable: Frequency and Duration.
Built-In HP-IB (IEEE-488) for interfacing with microprocessor and peripherals

4.0 SYSTEM PERFORMANCE

4.1 MEASURING ACCURACY AND SPEED

4.1.1 X-Y Stage overall accuracy for X-Y Motion: ± .0002" (.005mm)
Maximum deviation within one (1) inch: ±.00010" (.0025mm)
Position repeatability: ±.00005" (.0013mm)

4.1.2 Z-Axis digital resolution: .0001" (.002mm)
Positioning Accuracy: ±.0002" (.004mm)
Squareness to X-Y axis within .0001" (.0025mm) per inch of Z travel.

4.1.3 VIDEO ACCURACY X-Y FIELD
Edge location resolution (horizontal and vertical) is .0002" (.005mm), low magnification, .00002" (.0005mm) high magnification.
Accuracy of video edge measurement is ±.0003" (.0076mm) low magnification, ±.000035" (.001mm) high magnification from center field.

4.1.4 VIDEO FOCAL ACCURACY (Z)
Z-axis positions can be determined to ±.0005" (.013mm) accuracy.

4.1.5 TABLE TRAVEL RATES
X-Y axes: 4 inch/second maximum
Z axes: 1 inch/second maximum
Maximum time including settle time corner to corner: 6 seconds

4.1.6 VIDEO MEASUREMENT RATE
One X-Y point per second is measured, identified and analyzed.
Z Axis measurements average approximately 3 seconds each.

4.2 CALCULATION AND PRINTING SPEED

4.2.1 HP-9826 CALCULATOR WITH HP2671G PRINTER
Speed of calculations will vary from a few hundred msecs. to up to 950 msecs. for advanced statistical routine per block of measurement. The 2671 Graphics Printer will print 120 characters/second (16.2 character/in @ 132 character/line) and has a 2K byte ASCII buffer so data is being gathered with little delay between blocks of measurement.

5.0 ENVIRONMENTAL

Temperature:	Recommended operating temperature: 68°F ± 2°
	Maximum recommended operating temperature: 78° F
	Maximum recommended temperature rate of change: 2°F/hour
Vibration:	Environmental vibration amplitudes should not exceed 200 micro-g's at frequencies below 10Hz
Humidity:	30 to 80% RH Non Condensing

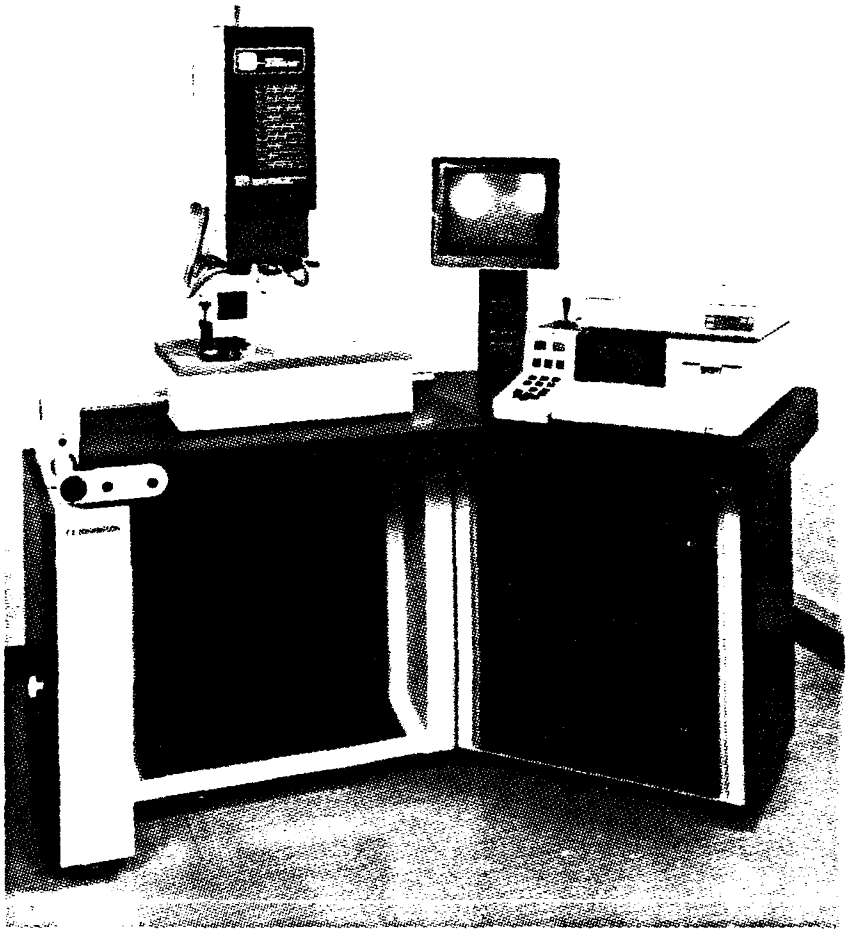


FIGURE A-1

Vidicom Qualifier 1210 Inspection System

APPENDIX B

Firing Pin Program

```
**************************************************
Block Number(   1)  Label(      )  Lights(P        )
Destination of Output              Unit of Meas (IN)
Measured Vals (  P  )              Out of Tol (    )
Position Reference (M)
Prompt
(SET .245 INCHES LEFT OF .13 DIA. CENTER           )
Width          (  .13000)   # Points    ( 3)
Upper Tol      (0.00000)    Lower Tol   (0.00000)
Angle          (  +0.000)   Length      (  .15000)
Nominal Location
X (  -.24500)   Y ( +0.00000)   Z ( +0.00000)
No Locational Tolerance
**************************************************

**************************************************
Block Number(   2)  Label(      )  Lights(P        )
Destination of Output              Unit of Meas (IN)
Measured Vals (  P  )              Out of Tol (   P)
Angle Reference    (A)
Width          (  .13000)   # Points    ( 3)
Upper Tol      (0.00000)    Lower Tol   (0.00000)
Angle          (  +0.000)   Length      (  .15000)
Nominal Location
X (  -.09494)   Y ( +0.00000)   Z ( +0.00000)
No Locational Tolerance
**************************************************

**************************************************
Block Number(   3)  Label(      )  Lights(P        )
Destination of Output              Unit of Meas (IN)
Measured Vals (  P  )              Out of Tol (   P)
Set xyz (Reset)
X (A)( +0.00000)
Nominal Location
X ( +0.00000)   Y (  -.03250)   Z (  +.05630)
No Locational Tolerance (Seek)
Magnification (H)    Direction of Grab (X) (BI-DR)
**************************************************

**************************************************
Block Number(   4)  Label(      )  Lights(P        )
Destination of Output              Unit of Meas (IN)
Measured Vals (  P  )              Out of Tol (   P)
Width          (  .13000)   # Points    ( 1)
Upper Tol      (0.00000)    Lower Tol   ( .00200)
Angle          (  +0.000)   Length      ( 0.00000)
Nominal Location
X (  -.30000)   Y ( +0.00000)   Z ( +0.00000)
No Locational Tolerance
**************************************************
```

```
************************************************
Block Number(  5)  Label(     )  Lights(P          )
Destination of Output             Unit of Meas (IN)
Measured Vals (  P  )             Out of Tol (  P)
Width            (  .13000)   # Points    ( 1)
Upper Tol        (0.00000)    Lower Tol   ( .00200)
Angle            (  +0.000)   Length      ( 0.00000)
Nominal Location
X (  -.20000)    Y ( +0.00000)    Z ( +0.00000)
No Locational Tolerance
************************************************

************************************************
Block Number(  6)  Label(     )  Lights(P          )
Destination of Output             Unit of Meas (IN)
Measured Vals (  P  )             Out of Tol (  P)
Width            (  .13000)   # Points    ( 1)
Upper Tol        (0.00000)    Lower Tol   ( .00200)
Angle            (  +0.000)   Length      ( 0.00000)
Nominal Location
X (  -.15000)    Y ( +0.00000)    Z ( +0.00000)
No Locational Tolerance
************************************************

************************************************
Block Number(  7)  Label(     )  Lights(P          )
Destination of Output             Unit of Meas (IN)
Measured Vals (  P  )             Out of Tol (  P)
Radius           (  .15625)
Upper Tol        ( .01563)  Lower Tol  ( .01563)
Start Degree (+160.000) End Degree (+100.000)
# of Points   (20)
Nominal Location
X (  -.34375)    Y (  -.22125)    Z ( +0.00000)
No Locational Tolerance
************************************************

************************************************
Block Number(  8)  Label(     )  Lights(P          )
Destination of Output             Unit of Meas (IN)
Measured Vals (  P  )             Out of Tol (  P)
Radius           (  .15625)
Upper Tol        ( .01563)  Lower Tol  ( .15630)
Start Degree (+260.000) End Degree (+200.000)
# of Points   (20)
Nominal Location
X (  -.34375)    Y (  +.22125)    Z ( +0.00000)
No Locational Tolerance
************************************************
```

```
**************************************************
Block Number(  9)  Label(    )  Lights(P          )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Nominal Location
X (  -.50000)   Y (  -.23840)   Z ( +0.00000)
XYZ Locational Tolerance
Xup ( .01000)   Yup (0.00000)   Zup (0.00000)
Xlw (0.00000)   Ylw (0.00000)   Zlw (0.00000)
**************************************************

**************************************************
Block Number( 10)  Label(    )  Lights(P          )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Nominal Location
X (  -.50000)   Y (  +.23840)   Z ( +0.00000)
XYZ Locational Tolerance
Xup ( .01000)   Yup (0.00000)   Zup (0.00000)
Xlw (0.00000)   Ylw (0.00000)   Zlw (0.00000)
**************************************************

**************************************************
Block Number( 11)  Label(    )  Lights(P          )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Width         (  .50000)   # Points    ( 1)
Upper Tol     (0.00000)    Lower Tol   ( .01000)
Angle         (  +0.000)   Length      ( 0.00000)
Nominal Location
X (  -.80000)   Y ( +0.00000)   Z ( +0.00000)
No Locational Tolerance
**************************************************

**************************************************
Block Number( 12)  Label(    )  Lights(P          )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Width         (  .50000)   # Points    ( 1)
Upper Tol     (0.00000)    Lower Tol   ( .01000)
Angle         (  +0.000)   Length      ( 0.00000)
Nominal Location
X (  -.67500)   Y ( +0.00000)   Z ( +0.00000)
No Locational Tolerance
**************************************************
```

```
**************************************************
Block Number( 13)  Label(    )  Lights(P               )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Width          (  .50000)   # Points   ( 1)
Upper Tol      (0.00000)    Lower Tol  ( .01000)
Angle          (  +0.000)   Length     ( 0.00000)
Nominal Location
X (  -.55000)   Y ( +0.00000)   Z ( +0.00000)
No Locational Tolerance
**************************************************

**************************************************
Block Number( 14)  Label(    )  Lights(P               )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Nominal Location
X (  -.80000)   Y (  +.25000)   Z ( +0.00000)
XYZ Locational Tolerance
Xup (0.00000)   Yup (0.00000)   Zup (0.00000)
Xlw (0.00000)   Ylw ( .01000)   Zlw (0.00000)
**************************************************

**************************************************
Block Number( 15)  Label(    )  Lights(P               )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Nominal Location
X (  -.67500)   Y (  +.25000)   Z ( +0.00000)
XYZ Locational Tolerance
Xup (0.00000)   Yup (0.00000)   Zup (0.00000)
Xlw (0.00000)   Ylw ( .01000)   Zlw (0.00000)
**************************************************

**************************************************
Block Number( 16)  Label(    )  Lights(P               )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Nominal Location
X (  -.55000)   Y (  +.25000)   Z ( +0.00000)
XYZ Locational Tolerance
Xup (0.00000)   Yup (0.00000)   Zup (0.00000)
Xlw (0.00000)   Ylw ( .01000)   Zlw (0.00000)
**************************************************
```

APPENDIX B (CONT'D)

```
************************************************
Block Number( 21)  Label(    )  Lights(P              )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Nominal Location
X (  -.85300)   Y (  +.33000)   Z (  +.25300)
XYZ Locational Tolerance
Xup ( .00200)   Yup (0.00000)   Zup (0.00000)
Xlw (0.00000)   Ylw (0.00000)   Zlw (0.00000)
************************************************

************************************************
Block Number( 22)  Label(    )  Lights(P              )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Pol Org (A)
First Angle   ( +45.000)    # of pts (10)
Start Point   (  +.00500)  End Point (  +.01500)
Second Angle (+180.000)    # of Pts (10)
Start Point   (  +.05000)  End Point (  +.20000)
Upper Tol     ( 0.0000)    Lower Tol ( 0.0000)
Nominal Location
X (  -.87300)   Y (  -.43600)   Z ( +0.00000)
No Locational Tolerance
Secondary Feature
(XYZ to B)   Blk# ( 20)
X (  +.02000)      Y (  +.10600)      Z (  +.25300)
Xup( .01000)       Yup(0.00000)       Zup(0.00000)
Xlw(0.00000)       Ylw(0.00000)       Zlw(0.00000)
(XYZ to B)   Blk# ( 21)
X (  +.02000)      Y (  +.76600)      Z (  +.25300)
Xup( .01000)       Yup(0.00000)       Zup(0.00000)
Xlw(0.00000)       Ylw(0.00000)       Zlw(0.00000)
************************************************

*********************************************  ***
Block Number( 23)  Label(    )  Lights(P R            )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Angle               ( +45.000)
Tol Up              ( 1.0000)     Tol Lw      ( 1.0000)
Straightness Tol (0.00000)     Length      (  .02400)
# of Points         (40)
Nominal Location
R (  +.01600)   A ( +45.000)    Z ( +0.00000)
RAZ Locational Tolerance
Rup (0.00000)   Aup (9.00000)   Zup (0.00000)
Rlw (0.00000)   Alw (9.00000)   Zlw (0.00000)
************************************************
```

```
**************************************************
Block Number( 17)  Label(    )  Lights(P          )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Nominal Location
X (  -.55000)   Y (  -.25000)   Z ( +0.00000)
XYZ Locational Tolerance
Xup (0.00000)   Yup (0.00000)   Zup (0.00000)
Xlw (0.00000)   Ylw ( .01000)   Zlw (0.00000)
**************************************************

**************************************************
Block Number( 18)  Label(    )  Lights(P          )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Nominal Location
X (  -.67500)   Y (  -.25000)   Z ( +0.00000)
XYZ Locational Tolerance
Xup (0.00000)   Yup (0.00000)   Zup (0.00000)
Xlw (0.00000)   Ylw ( .01000)   Zlw (0.00000)
**************************************************

**************************************************
Block Number( 19)  Label(    )  Lights(P          )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Nominal Location
X (  -.80000)   Y (  -.25000)   Z ( +0.00000)
XYZ Locational Tolerance
Xup (0.00000)   Yup (0.00000)   Zup (0.00000)
Xlw (0.00000)   Ylw ( .01000)   Zlw (0.00000)
**************************************************

**************************************************
Block Number( 20)  Label(    )  Lights(P          )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Nominal Location
X (  -.85300)   Y (  -.33000)   Z (  +.25300)
XYZ Locational Tolerance
Xup ( .00200)   Yup (0.00000)   Zup (0.00000)
Xlw (0.00000)   Ylw (0.00000)   Zlw (0.00000)
**************************************************
```

```
****************************************************
Block Number( 24)  Label(    )  Lights(P          )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Radius          (   .03000)
Upper Tol       (0.00000)  Lower Tol  ( .01000)
Start Degree (+160.000) End Degree (+110.000)
# of Points   (20)
Nominal Location
X (  -.82300)   Y (  -.28000)   Z ( +0.00000)
No Locational Tolerance
****************************************************

****************************************************
Block Number( 25)  Label(    )  Lights(P          )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Pol Org (A)
First Angle  (+180.000)    # of pts (10)
Start Point  (   +.05000)  End Point (   +.20000)
Second Angle (+315.000)    # of Pts (10)
Start Point  (   +.00500)  End Point (   +.01500)
Upper Tol    ( 0.0000)     Lower Tol ( 0.0000)
Nominal Location
X (  -.87300)   Y (  +.43600)   Z ( +0.00000)
No Locational Tolerance
Secondary Feature
(XYZ to B)   Blk# ( 20)
X (  +.02000)      Y (  +.76600)      Z (  +.25300)
Xup( .01000)       Yup(0.00000)       Zup(0.00000)
Xlw(0.00000)       Ylw(0.00000)       Zlw(0.00000)
(XYZ to B)   Blk# ( 21)
X (  +.02000)      Y (  +.10600)      Z (  +.25300)
Xup( .01000)       Yup(0.00000)       Zup(0.00000)
Xlw(0.00000)       Ylw(0.00000)       Zlw(0.00000
****************************************************

****************************************************
Block Number( 26)  Label(    )  Lights(P R        )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Angle                (+135.000)
Tol Up               ( 1.0000)    Tol Lw     ( 1.0000)
Straightness Tol (0.00000)    Length     (   .02400)
# of Points          (40)
Nominal Location
R (  +.01600)   A ( -45.000)    Z ( +0.00000)
RAZ Locational Tolerance
Rup (0.00000)   Aup (9.00000)   Zup (0.00000)
Rlw (0.00000)   Alw (9.00000)   Zlw (0.00000)
****************************************************
```

```
*************************************************
Block Number( 27)  Label(    )  Lights(P         )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Radius        (  .03000)
Upper Tol     (0.00000)  Lower Tol  ( .01000)
Start Degree (+250.000) End Degree (+200.000)
# of Points  (20)
Nominal Location
X (  -.82300)   Y (  +.28000)   Z ( +0.00000)
No Locational Tolerance
*************************************************

*************************************************
Block Number( 28)  Label(    )  Lights(P         )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Width         (  .87200)   # Points    ( 1)
Upper Tol     (0.00000)    Lower Tol   ( .00200)
Angle         (  +0.000)   Length      ( 0.00000)
Nominal Location
X ( -1.10000)   Y ( +0.00000)   Z ( +0.00000)
XYZ Locational Tolerance
Xup (0.00000)   Yup ( .00100)   Zup (0.00000)
Xlw (0.00000)   Ylw ( .00100)   Zlw (0.00000)
*************************************************

*************************************************
Block Number( 29)  Label(    )  Lights(P         )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Width         (  .87200)   # Points    ( 1)
Upper Tol     (0.00000)    Lower Tol   ( .00200)
Angle         (  +0.000)   Length      ( 0.00000)
Nominal Location
X ( -1.00000)   Y ( +0.00000)   Z ( +0.00000)
XYZ Locational Tolerance
Xup (0.00000)   Yup ( .00100)   Zup (0.00000)
Xlw (0.00000)   Ylw ( .00100)   Zlw (0.00000)
*************************************************

*************************************************
Block Number( 30)  Label(    )  Lights(P         )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Width         (  .87200)   # Points    ( 1)
Upper Tol     (0.00000)    Lower Tol   ( .00200)
Angle         (  +0.000)   Length      ( 0.00000)
Nominal Location
X (  -.90000)   Y ( +0.00000)   Z ( +0.00000)
XYZ Locational Tolerance
Xup (0.00000)   Yup ( .00100)   Zup (0.00000)
Xlw (0.00000)   Ylw ( .00100)   Zlw (0.00000)
*************************************************
```

```
**************************************************
Block Number( 31)  Label(    )  Lights(P              )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Nominal Location
X ( -1.27500)   Y (  -.13000)   Z ( +0.00000)
XYZ Locational Tolerance
Xup (0.00000)   Yup (0.00000)   Zup (0.00000)
Xlw ( .00500)   Ylw (0.00000)   Zlw (0.00000)
**************************************************

**************************************************
Block Number( 32)  Label(    )  Lights(P              )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Nominal Location
X ( -1.27500)   Y (  +.13000)   Z ( +0.00000)
XYZ Locational Tolerance
Xup (0.00000)   Yup (0.00000)   Zup (0.00000)
Xlw ( .00500)   Ylw (0.00000)   Zlw (0.00000)
**************************************************

**************************************************
Block Number( 33)  Label(    )  Lights(P              )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Nominal Location
X ( -1.19000)   Y (  -.21800)   Z (  +.37757)
No Locational Tolerance (Seek)
Magnification (L)    Direction of Grab (X) (BI-DR)
Secondary Feature
(XYZ to B)   Blk# ( 31)
X (  +.08500)       Y (  +.08800)       Z (  +.37757)
Xup(0.00000)        Yup(0.00000)        Zup(0.00000)
Xlw( .01000)        Ylw(0.00000)        Zlw(0.00000)
(XYZ to B)   Blk# ( 32)
X (  +.08500)       Y (  +.34800)       Z (  +.37757)
Xup(0.00000)        Yup(0.00000)        Zup(0.00000)
Xlw( .01000)        Ylw(0.00000)        Zlw(0.00000)
**************************************************

**************************************************
Block Number( 34)  Label(    )  Lights(P              )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Nominal Location
X ( -1.19000)   Y (  +.21800)   Z (  +.37757)
No Locational Tolerance (Seek)
Magnification (L)    Direction of Grab (X) (BI-DR)
Secondary Feature
(XYZ to B)   Blk# ( 31)
X (  +.08500)       Y (  +.34800)       Z (  +.37757)
Xup(0.00000)        Yup(0.00000)        Zup(0.00000)
Xlw( .01000)        Ylw(0.00000)        Zlw(0.00000)
(XYZ to B)   Blk# ( 32)
X (  +.08500)       Y (  +.08800)       Z (  +.37757)
Xup(0.00000)        Yup(0.00000)        Zup(0.00000)
Xlw( .01000)        Ylw(0.00000)        Zlw(0.00000)
**************************************************
```

APPENDIX B (CONT'D)

```
***********************************************
Block Number( 35)  Label(    )  Lights(P        )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Width          (  .31200)   # Points    ( 1)
Upper Tol      ( .01000)    Lower Tol   ( .01000)
Angle          (  +0.000)   Length      ( 0.00000)
Nominal Location
X ( -1.24800)   Y ( +0.00000)   Z ( +0.00000)
No Locational Tolerance
***********************************************

***********************************************
Block Number( 36)  Label(    )  Lights(P        )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Nominal Location
X ( -1.24800)   Y (  -.16100)   Z ( +0.00000)
XYZ Locational Tolerance
Xup (0.00000)   Yup (0.00000)   Zup (0.00000)
Xlw (0.00000)   Ylw ( .02000)   Zlw (0.00000)
***********************************************

***********************************************
Block Number( 37)  Label(    )  Lights(P        )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Nominal Location
X ( -1.24800)   Y (  +.16100)   Z ( +0.00000)
XYZ Locational Tolerance
Xup (0.00000)   Yup (0.00000)   Zup (0.00000)
Xlw (0.00000)   Ylw ( .02000)   Zlw (0.00000)
***********************************************

***********************************************
Block Number( 38)  Label(    )  Lights(P        )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Nominal Location
X ( -1.20562)   Y (  +.12475)   Z ( +0.00000)
No Locational Tolerance (Seek)
Magnification (L)    Direction of Grab (Y) (BI-DR)
Secondary Feature
(XYZ to B)   Blk# ( 37)
X (  +.04238)     Y (  +.03125)     Z ( +0.00000)
Xup(0.00000)      Yup( .01563)      Zup(0.00000)
Xlw(0.00000)      Ylw( .01563)      Zlw(0.00000)
***********************************************
```

```
**************************************************
Block Number( 39)  Label(    )  Lights(P          )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Nominal Location
X ( -1.20562)   Y (  -.12475)   Z ( +0.00000)
No Locational Tolerance (Seek)
Magnification (L)    Direction of Grab (Y) (BI-DR)
Secondary Feature
(XYZ to B)   Blk# ( 36)
X (  +.04238)     Y (  +.03125)     Z ( +0.00000)
Xup(0.00000)      Yup( .01563)      Zup(0.00000)
Xlw(0.00000)      Ylw( .01563)      Zlw(0.00000)
**************************************************

**************************************************
Block Number( 40)  Label(    )  Lights(P          )
Destination of Output           Unit of Meas (IN)
Measured Vals (  P  )           Out of Tol (  P)
Nominal Location
X (  -.24500)   Y ( +0.00000)   Z ( +0.00000)
No Locational Tolerance (Locate)
**************************************************

**************************************************
Block Number  ( 41) Type (   PART)  Offset ( CART)
First Block (   1)  Last Block ( 40) # Times (   9)
X-off( +0.00000) Y-off( +0.00000) Z-off( +0.00000)
**************************************************
```

APPENDIX C

Firing Pin Measurements

PROGRAM NAME	RUN #	DATE	TIME
IFIRINGPIN	5		

Blk	Function	Label	Sym	Nom.Val.	Act.Val.	U. Tol.	L. Tol.	Dev>Nom	Tol Exc
POSITION REFERENCE									
1	WIDTH		WID	.13000	.12814				
			MIN		.12804				
			MAX		.12826				
		NOM LOC	X	-.24500	-.24500				
			Y	0.00000	0.00000				
			Z	0.00000	0.00000				
ANGLE REFERENCE (AUTO)									
2	WIDTH		WID	.13000	.12813				
			MIN		.12808				
			MAX		.12816				
		NOM LOC	X	-.09495	-.09493				
			Y	0.00000	0.00000				
			Z	0.00000	0.00000				
3	NOM LOCAT		X	0.00000	.00067				
			Y	-.03250	-.03243				
			Z	.05630	.05669				
		RESET	X	.00067	0.00000				
4	WIDTH		WID	.13000	.12830	0.00000	.00200	-.00170	----
		NOM LOC	X	-.30000	-.30002				
			Y	0.00000	.00011				
			Z	0.00000	0.00000				
5	WIDTH		WID	.13000	.12831	0.00000	.00200	-.00169	----
		NOM LOC	X	-.20000	-.20003				
			Y	0.00000	.00006				
			Z	0.00000	0.00000				
6	WIDTH		WID	.13000	.12834	0.00000	.00200	-.00166	----
		NOM LOC	X	-.15000	-.15009				
			Y	0.00000	.00001				
			Z	0.00000	0.00000				
7	RADIUS		RAD	.1563	.1607	.0156	.0156	.0044	++
			MIN		.1600				
			MAX		.1615				
		NOM LOC	X	-.3438	-.3460				
			Y	-.2213	-.2241				
			Z	0.0000	0.0000				
8	RADIUS		RAD	.1563	.1599	.0156	.1563	.0037	+

Blk	Function	Label Sym	Nom.Val.	Act.Val.	U. Tol.	L. Tol.	Dev>Nom	Tol Exc
		MIN		.1591				
		MAX		.1605				
		NOM LOC X	-.3438	-.3462				
		Y	.2213	.2239				
		Z	0.0000	0.0000				
9	NOM LOCAT	X	-.5000	-.5062	.0100	0.0000	.0062	+++
		Y	-.2384	-.2389				
		Z	0.0000	0.0000				
10	NOM LOCAT	X	-.5000	-.5061	.0100	0.0000	.0061	+++
		Y	.2384	.2388				
		Z	0.0000	0.0000				
11	WIDTH	WID	.5000	.4969	0.0000	.0100	-.0031	--
		NOM LOC X	-.8000	-.8006				
		Y	0.0000	.0005				
		Z	0.0000	0.0000				
12	WIDTH	WID	.5000	.4963	0.0000	.0100	-.0037	--
		NOM LOC X	-.6750	-.6757				
		Y	0.0000	.0005				
		Z	0.0000	0.0000				
13	WIDTH	WID	.5000	.4965	0.0000	.0100	-.0035	--
		NOM LOC X	-.5500	-.5495				
		Y	0.0000	.0002				
		Z	0.0000	0.0000				
14	NOM LOCAT	X	-.8000	-.8003				
		Y	.2500	.2488	0.0000	.0100	-.0012	-
		Z	0.0000	0.0000				
15	NOM LOCAT	X	-.6750	-.6754				
		Y	.2500	.2486	0.0000	.0100	-.0014	-
		Z	0.0000	0.0000				
16	NOM LOCAT	X	-.5500	-.5497				
		Y	.2500	.2485	0.0000	.0100	-.0015	-
		Z	0.0000	0.0000				
17	NOM LOCAT	X	-.5500	-.5498				
		Y	-.2500	-.2477	0.0000	.0100	-.0023	-
		Z	0.0000	0.0000				
18	NOM LOCAT	X	-.6750	-.6747				
		Y	-.2500	-.2478	0.0000	.0100	-.0022	-
		Z	0.0000	0.0000				
19	NOM LOCAT	X	-.8000	-.8007				
		Y	-.2500	-.2475	0.0000	.0100	-.0025	-
		Z	0.0000	0.0000				
20	NOM LOCAT	X	-.8530	-.8546	.0020	0.0000	.0016	++++

Blk Function	Label Sym	Nom.Val.	Act.Val.	U. Tol.	L. Tol.	Dev>Nom	Tol Ex
	Y	-.4000	-.4009				
	Z	0.0000	0.0000				
21 NOM LOCAT	X	-.8530	-.8545	.0020	0.0000	.0015	+++
	Y	.4000	.3996				
	Z	0.0000	0.0000				
POLAR ORIGIN at ACTUAL							
22 VERTEX	ANG	135.000	136.542				
	NOM LOC X	-.8730	-.8805				
	Y	-.4360	-.4345				
	Z	0.0000	0.0000				
	X to 20	.0200	.0259	.0100	0.0000	.0059	+++
	Y	.1060	.0336				
	Z	.2530	0.0000				
	X to 21	.0200	.0261	.0100	0.0000	.0061	+++
	Y	.7660	.8341				
	Z	.2530	0.0000				
23 LINE	ANG	45.0000	44.9549	1.0000	1.0000	-.0451	-
	NOM LOC R	.01600	.01608				
	A	45.0000	39.3636	9.0000	9.0000	-5.6364	---
	Z	0.00000	0.00000				
24 RADIUS	RAD	.0300	.0288	0.0000	.0100	-.0012	-
	MIN		.0282				
	MAX		.0294				
	NOM LOC X	-.8230	-.8255				
	Y	-.2800	-.2774				
	Z	0.0000	0.0000				
POLAR ORIGIN at ACTUAL							
25 VERTEX	ANG	135.000	136.314				
	NOM LOC X	-.8730	-.8796				
	Y	.4360	.4351				
	Z	0.0000	0.0000				
	X to 20	.0200	.0249	.0100	0.0000	.0049	++
	Y	.7660	.8360				
	Z	.2530	0.0000				
	X to 21	.0200	.0251	.0100	0.0000	.0051	+++
	Y	.1060	.0354				
	Z	.2530	0.0000				
26 LINE	ANG	135.0000	135.6284	1.0000	1.0000	.6284	+++
	NOM LOC R	.01600	.01605				
	A	-45.0000	-39.8904	9.0000	9.0000	-5.1096	---
	Z	0.00000	0.00000				
27 RADIUS	RAD	.0300	.0294	0.0000	.0100	-.0006	-
	MIN		.0291				
	MAX		.0298				
	NOM LOC X	-.8230	-.8252				
	Y	.2800	.2790				
	Z	0.0000	0.0000				

Blk	Function	Label	Sym	Nom.Val.	Act.Val.	U. Tol.	L. Tol.	Dev>Nom	Tol Exc
28	WIDTH		WID	.87200	.87133	0.00000	.00200	-.00067	--
		NOM LOC	X	-1.10000	-1.09992				
			Y	0.00000	.00040	.00100	.00100	.00040	++
			Z	0.00000	0.00000				
29	WIDTH		WID	.87200	.87143	0.00000	.00200	-.00057	--
		NOM LOC	X	-1.00000	-1.00004				
			Y	0.00000	.00030	.00100	.00100	.00030	++
			Z	0.00000	0.00000				
30	WIDTH		WID	.87200	.87130	0.00000	.00200	-.00070	--
		NOM LOC	X	-.90000	-.89994				
			Y	0.00000	.00025	.00100	.00100	.00025	+
			Z	0.00000	0.00000				
31	NOM LOCAT		X	-1.2750	-1.2725	0.0000	.0050	-.0025	--
			Y	-.1300	-.1303				
			Z	0.0000	0.0000				
32	NOM LOCAT		X	-1.2750	-1.2726	0.0000	.0050	-.0024	--
			Y	.1300	.1298				
			Z	0.0000	0.0000				
33	NOM LOCAT		X	-1.1900	-1.1909				
			Y	-.4300	-.4309				
			Z	0.0000	0.0000				
		X to 31		.0850	.0816	0.0000	.0100	-.0034	--
		Y		.0880	.3007				
		Z		.3776	0.0000				
		X to 32		.0850	.0817	0.0000	.0100	-.0033	--
		Y		.3480	.5608				
		Z		.3776	0.0000				
34	NOM LOCAT		X	-1.1900	-1.1913				
			Y	.4300	.4307				
			Z	0.0000	0.0000				
		X to 31		.0850	.0812	0.0000	.0100	-.0038	--
		Y		.3480	.5610				
		Z		.3776	0.0000				
		X to 32		.0850	.0813	0.0000	.0100	-.0037	--
		Y		.0880	.3009				
		Z		.3776	0.0000				
35	WIDTH		WID	.3120	.3141	.0100	.0100	.0021	+
		NOM LOC	X	-1.2480	-1.2476				
			Y	0.0000	.0007				
			Z	0.0000	0.0000				
36	NOM LOCAT		X	-1.2480	-1.2480				
			Y	-.1610	-.1562	0.0000	.0200	-.0048	-
			Z	0.0000	0.0000				
37	NOM LOCAT		X	-1.2480	-1.2473				

Blk	Function	Label	Sym	Nom.Val.	Act.Val.	U. Tol.	L. Tol.	Dev>Nom	Tol E
			Y	.1610	.1577	0.0000	.0200	-.0033	-
			Z	0.0000	0.0000				
38	NOM LOCAT		X	-1.2056	-1.2061				
			Y	.1247	.1268				
			Z	0.0000	0.0000				
		X to 37		.0424	.0411				
		Y		.0313	.0309	.0156	.0156	-.0004	-
		Z		0.0000	0.0000				
39	NOM LOCAT		X	-1.2056	-1.2052				
			Y	-.1247	-.1263				
			Z	0.0000	0.0000				
		X to 36		.0424	.0428				
		Y		.0313	.0299	.0156	.0156	-.0013	-
		Z		0.0000	0.0000				
40	NOM LOCAT		X	-1.2212	-1.2287				
			Y	.1400	.1404				
			Z	0.0000	0.0000				
		X to 33		.0313	.0379	.0156	.0156	.0066	++
		Y		.3580	.5713				
		Z		.3776	0.0000				
		X to 34		.0313	.0374	.0156	.0156	.0061	++
		Y		.0780	.2903				
		Z		.3776	0.0000				
41	NOM LOCAT		X	-1.2212	-1.2286				
			Y	-.1400	-.1409				
			Z	0.0000	0.0000				
		X to 33		.0313	.0377	.0156	.0156	.0064	++
		Y		.0780	.2900				
		Z		.3776	0.0000				
		X to 34		.0313	.0373	.0156	.0156	.0060	++
		Y		.3580	.5716				
		Z		.3776	0.0000				
42	NOM LOCAT		X	-.2450	-.2450				
			Y	0.0000	0.0000				
			Z	0.0000	0.0000				

TECHNICAL REPORT INTERNAL DISTRIBUTION LIST

	NO. OF COPIES
CHIEF, DEVELOPMENT ENGINEERING BRANCH	
ATTN: SMCAR-CCB-D	1
-DA	1
-DC	1
-DM	1
-DP	1
-DR	1
-DS (SYSTEMS)	1
CHIEF, ENGINEERING SUPPORT BRANCH	
ATTN: SMCAR-CCB-S	1
-SE	1
CHIEF, RESEARCH BRANCH	
ATTN: SMCAR-CCB-R	2
-R (ELLEN FOGARTY)	1
-RA	1
-RM	1
-RP	1
-RT	1
TECHNICAL LIBRARY	5
ATTN: SMCAR-CCB-TL	
TECHNICAL PUBLICATIONS & EDITING UNIT	2
ATTN: SMCAR-CCB-TL	
DIRECTOR, OPERATIONS DIRECTORATE	1
ATTN: SMCWV-OD	
DIRECTOR, PROCUREMENT DIRECTORATE	1
ATTN: SMCWV-PP	
DIRECTOR, PRODUCT ASSURANCE DIRECTORATE	1
ATTN: SMCWV-QA	

NOTE: PLEASE NOTIFY DIRECTOR, BENET LABORATORIES, ATTN: SMCAR-CCB-TL, OF ANY ADDRESS CHANGES.

TECHNICAL REPORT EXTERNAL DISTRIBUTION LIST

	NO. OF COPIES
ASST SEC OF THE ARMY RESEARCH AND DEVELOPMENT ATTN: DEPT FOR SCI AND TECH THE PENTAGON WASHINGTON, D.C. 20310-0103	1
ADMINISTRATOR DEFENSE TECHNICAL INFO CENTER ATTN: DTIC-FDAC CAMERON STATION ALEXANDRIA, VA 22304-6145	12
COMMANDER US ARMY ARDEC ATTN: SMCAR-AEE	1
SMCAR-AES, BLDG. 321	1
SMCAR-AET-O, BLDG. 351N	1
SMCAR-CC	1
SMCAR-CCP-A	1
SMCAR-FSA	1
SMCAR-FSM-E	1
SMCAR-FSS-D, BLDG. 94	1
SMCAR-MSI (STINFO) PICATINNY ARSENAL, NJ 07806-5000	2
DIRECTOR US ARMY BALLISTIC RESEARCH LABORATORY ATTN: SLCBR-DD-T, BLDG. 305 ABERDEEN PROVING GROUND, MD 21005-5066	1
DIRECTOR US ARMY MATERIEL SYSTEMS ANALYSIS ACTV ATTN: AMXSY-MP ABERDEEN PROVING GROUND, MD 21005-5071	1
COMMANDER HQ, AMCCOM ATTN: AMSMC-IMP-L ROCK ISLAND, IL 61299-6000	1

	NO. OF COPIES
COMMANDER ROCK ISLAND ARSENAL ATTN: SMCRI-ENM ROCK ISLAND, IL 61299-5000	1
DIRECTOR US ARMY INDUSTRIAL BASE ENGR ACTV ATTN: AMXIB-P ROCK ISLAND, IL 61299-7260	1
COMMANDER US ARMY TANK-AUTMV R&D COMMAND ATTN: AMSTA-DDL (TECH LIB) WARREN, MI 48397-5000	1
COMMANDER US MILITARY ACADEMY ATTN: DEPARTMENT OF MECHANICS WEST POINT, NY 10996-1792	1
US ARMY MISSILE COMMAND REDSTONE SCIENTIFIC INFO CTR ATTN: DOCUMENTS SECT, BLDG. 4484 REDSTONE ARSENAL, AL 35898-5241	2
COMMANDER US ARMY FGN SCIENCE AND TECH CTR ATTN: DRXST-SD 220 7TH STREET, N.E. CHARLOTTESVILLE, VA 22901	1
COMMANDER US ARMY LABCOM MATERIALS TECHNOLOGY LAB ATTN: SLCMT-IML (TECH LIB) WATERTOWN, MA 02172-0001	2

NOTE: PLEASE NOTIFY COMMANDER, ARMAMENT RESEARCH, DEVELOPMENT, AND ENGINEERING CENTER, US ARMY AMCCOM, ATTN: BENET LABORATORIES, SMCAR-CCB-TL, WATERVLIET, NY 12189-4050, OF ANY ADDRESS CHANGES.

TECHNICAL REPORT EXTERNAL DISTRIBUTION LIST (CONT'D)

	NO. OF COPIES
COMMANDER US ARMY LABCOM, ISA ATTN: SLCIS-IM-TL 2800 POWDER MILL ROAD ADELPHI, MD 20783-1145	1
COMMANDER US ARMY RESEARCH OFFICE ATTN: CHIEF, IPO P.O. BOX 12211 RESEARCH TRIANGLE PARK, NC 27709-2211	1
DIRECTOR US NAVAL RESEARCH LAB ATTN: MATERIALS SCI & TECH DIVISION CODE 26-27 (DOC LIB) WASHINGTON, D.C. 20375	1 1
COMMANDER AIR FORCE ARMAMENT LABORATORY ATTN: AFATL/MN EGLIN AFB, FL 32542-5434	1
COMMANDER AIR FORCE ARMAMENT LABORATORY ATTN: AFATL/MNF EGLIN AFB, FL 32542-5434	1
METALS AND CERAMICS INFO CTR BATTELLE COLUMBUS DIVISION 505 KING AVENUE COLUMBUS, OH 43201-2693	1

NOTE: PLEASE NOTIFY COMMANDER, ARMAMENT RESEARCH, DEVELOPMENT, AND ENGINEERING CENTER, US ARMY AMCCOM, ATTN: BENET LABORATORIES, SMCAR-CCB-TL, WATERVLIET, NY 12189-4050, OF ANY ADDRESS CHANGES.

END
DATE
FILMED
9-88
DTIC